REPORT: Semi-annual

TIME PERIOD: July-December, 1993

NAME AND LOCATION: Alan Strahler, Boston University

CONTRACT NUMBER: NAS5-31369

OVERVIEW

During the reporting period, we continued our development and supporting research for the MODIS BRDF-Albedo and Land Cover/Land Cover Change products. This work included modeling, validation, and empirical studies involving data analysis, as well as the preparation of draft Algorithm Technical Basis Documents (ATBDs) as directed by the Team Leader.

TASK PROGRESS

BRDF/Albedo Product

Model Development

During this period, we completed the first phase of development of the hybrid model that predicts the BRDF of a natural vegetation cover composed of individual plant crowns using radiative transfer and geometric optics. This model utilizes conditional path length statistics and assumes that scattering and attenuation are constant within a plant crown and thus negative exponential functions of path lengths. A manuscript describing the model was submitted for publication in IEEE Transactions on Geoscience and Remote Sensing. (See publication list below.)

During this period, another manuscript was developed that documented the derivations needed to modify the Li-Strahler mutual shadowing model for the case of ellipsoids on a sloping background. The approach is simple in concept, using a transformation of axes, although the trigonometry is tedious. The manuscript was prepared in collaboration with USAF Phillips Laboratory, and was submitted to IEEE Transactions on Geoscience and Remote Sensing in late December.

We also continued development of the Monte Carlo surface BRDF model and the stochastic BRDF model. The former models the BRDF of a heterogeneous mixed pixel with topographic relief, and the latter models the influence of the atmosphere on the BRDF of a surface composed of three-dimensional envelopes of scattering media. Both of these efforts are directed toward the understanding of the spatial aggregation problem of land surface covers as it applies to BRDF.

We further completed the development of the four-stream model, which provides an analytical solution to the radiative transfer equation for a coupled atmosphere-nonlambertian surface system using a four-stream solution for multiple scattering. The surface BRDF is described empirically. A manuscript describing the model and its validation by comparison with very accurate iterative solutions to the radiative transfer equation was submitted to Applied Optics. (See publication list below.)

The four-stream model was then broadened by coupling it to a leaf canopy instead of an empirical non-Lambertian BRDF. This version is similar in concept to the previously-developed two-stream coupled analytical invertible model, but is more accurate because of the four-stream solution for multiple scattering. The four-stream approach is used for multiple scattering in both the atomsphere and canopy portions of the model. A manuscript describing the model was submitted to Journal of Geophysical Research in late December.

Model Validation

In collaboration with USAF Phillips Laboratory, we continued the construction of a distributed-parameter BRDF database for the Stanislaus National Forest for the purpose of albedo simulation. The database characterizes the geometric-optical characteristics of the vegetation cover of each 30-m pixel and calculates the albedo of the scene as a whole, using the terrain-dependent version of the mutual shadowing BRDF model. The solar spectrum albedo for the entire diverse scene is quite conservative, varying only by +-10% or so with different sun angles. This suggests that albedo generalizes well over large regions, which is an important conclusion for climatic modelers as well as for the preparation of our BRDF/Albedo product. The major variable influencing albedo is the nature of the surface cover, not the sun angle. The manuscript describing these results was partially developed, but is not likely to be submitted for publication until the first quarter of 1994.

Algorithm Development

We also began the development of the specific algorithm to be used to recover BRDF and albedo from MODIS and MISR data. The algorithm selects one of five candidate models to describe the BRDF: (1) a topographic model, driven by high-resolution digital terrain data; (2) a topographic model driven by a statistical characterization of slope facets; (3) a plane-parallel vegetation canopy model; (4) a geometric- optical model; and (5) an empirical model with physically-derived kernels that describe the shape of the BRDF function without providing specific physical parameters. The BRDF algorithm uses the Powell algorithm to fit the specific model to the observations in a forward, iterative procedure. By the close of the reporting period, we made significant progress, and expected to be able to meet the January 4, 1994, deadline for our first software delivery.

Algorithm Technical Basis Document

During the reporting period, we provided a first draft of the BRDF/Albedo product ATBD. However, the draft needed further work, and the Principal Investigator travelled to London for a week in December, collaborating with Team Member Peter Muller and Associate Team Member Mike Barnsley on a revised draft. At the close of the reporting period, the second draft was still under development.

Land Cover/Land-Cover Change Products

Land Cover

The first part of our study of the effects of resolution cell size on the distribution of land cover units was completed during this reporting period, and a manscript was submitted for publication. (See Publications section.) This research showed that estimates of the proportions of land cover types vary as a function of spatial resolution, with large changes occurring as aggregation becomes coarser and coarser. The changes are influenced by the initial coverage of each land cover class as related to that of other classes, and to the spatial pattern of occurrence (e.g., patch size and shape) of the class. The target area for the study is the Plumas National Forest in the Sierra Nevada of California. Work continued on the second part of this study, which focuses on measures of spatial pattern and structure of land cover units at fine resolution and their effects on coarse- resolution proportion estimation.

We also began work on the use of neural net classifiers for the land cover product. This involved a literature survey and development of a liason with Dr. Suchi Gopal, of the BU Geography Department, who has worked in this field and maintains ties to the BU Institute of Cognitive and Neural Science.

Land-Cover Change

During this period, we continued development of the change-vector technique for identifying and quantifying land-cover change processes. We further refined incorporation of land surface temperature, as inferred from AVHRR channels 4 and 5 using the split-window algorithm. The target region continued to be the west African Sahelian-Sudanian zone as imaged in a multitemporal AVHRR 1-km dataset kindly provided by J. Malingreau from the EC Joint Research Center at Ispra, Italy. We completed the revision of a manuscript describing the use of reflective, thermal, and spatial information in change process characterization. (See Publications section.)

Algorithm Development

A considerable effort during this period was devoted to the drafting of the Land Cover/Land-Cover Change Product ATBD. The document was circulated to all members of the Land Team in late July, and comments were received for incorporation in the final document as submitted during the fall Team Meeting.

In development of the Land Cover ATBD, Team Member Steve Running provided an alternative scenario for preparation of the Land Cover Parameter. In an independent study, he and Tom Loveland of EDC explored a simple 6-category classification that provided land covers suited for use in biogeochemical modeling as needed for the Photosynthesis-Net Primary Productivity Product. This classification used simple thresholding techniques on the EDC conterminous U. S. composited AVHRR dataset. Although the accuracy of this categorization has not been tested, the approach remains an alternative to neural nets that is very attractive due to its simplicity. With additional information from thermal channels, with topographic and broad climatic data, and with MISR directional data and/or the BRDF product, and without the "benefit" of compositing, the simple thresholding approach or an analogous technique may prove sufficiently accurate to obviate the need for more powerful, but more highly trained, classifiers such as those involving neural nets. Toward the close of the reporting period, we began a comparison of the two strategies -- thresholding and neural net classification -- on the Plumas National Forest dataset.

During the reporting period, our development of the Land Cover algorithm was slowed by lack of suitable datasets for development. By the close of the calendar year, the MODIS SDST was not been able to provide us with the 250- and 500-m imagery convolved from the TM data of the Plumas National Forest that we supplied. Also lacking was the registered AVHRR data from the EDC 1-km dataset. However, the SDST delivered these data soon after the close of the reporting period.

ANTICIPATED ACTIVITIES DURING THE NEXT QUARTER

BRDF/Albedo Product

Our primary activities during the next quarter for the BRDF/Albedo product will be (1) to continue to develop, refine and test the BRDF/Albedo algorithm and (2) to continue revision of the ATBD document and associated plans for producing the BRDF/Albedo product.

Land Cover/Land-Cover Change Product

We will continue the studies of land cover proportion estimation at coarse spatial resolutions, and finalize our results with a second manuscript to be ready during the middle of the quarter. We will begin trials comparing the neural net classifier to the Running-Loveland thresholding method. For the Land-Cover Change

Parameter, we will concentrate on further development and processing of the Asian LAC dataset being provided by Malingreau at the JRC in Ispra.

PROBLEMS/CORRECTIVE ACTIONS

During this reporting period, we did not encounter any significant problems requiring corrective actions beyond the every day problems that occur in research and algorithm development.

OTHER ACTIVITIES

1. Prof. Eric Lambin, who is carrying out the development of the Land-Cover Change parameter and algorithm, left in late August for a four-month leave of absence to be spent in J. Malingreau's laboratory at the EEC Joint Research Center in Ispra. In November, he resigned his position at BU to accept a research appointment at the ECC Joint Research Center, in Ispra, Italy. However, he plans to continue his work on land-cover change detection and modeling. We plan to add him to the MODIS Team as an Associate Team Member so that he can continue to interface with our effort.

2. Dr. Shunlin Liang departed on September 1 for the University of Maryland, where he has a postdoctoral appointment funded by GSFC as the AVHRR Pathfinder Land Scientist.

3. The Principal Investigator attended the NSF-sponsored meeting of scientists involved in the the Long-Term Ecological Research (LTER) program. The meeting was held in Estes Park, Colorado, September 18-22. At the meeting, several MODLAND PIs conducted a workshop session on the use of LTER sites as MODIS test sites for validation of Running's Photosynthesis-Net Primary Productivity Product, as well as other products. A specific proposal to NASA/NSF is under development by Running for the validation activity.

4. The Principal Investigator attended the MODIS Science Team Meeting at GSFC, September 29-October 1.

5. The Principal Investigator presented a paper describing MODIS and the MODLAND product suite at a meeting of the New England-St. Lawrence Valley division of the Association of American Geographers on October 8, 1993, at Keene, New Hampshire.

6. The Principal Investigator attended a BOREAS investigators' meeting held in Coolfont, West Virginia, during Oct. 20-22. Plans were developed for acquisition of aircraft imagery and ground support data during the BOREAS experiment that will primarily be of interest in development of the BRDF/Albedo product.

7. The Principal Investigator traveled to London, Dec. 3-11, to collaborate with Team Member Peter Muller and Associate Team

Member Mike Barnsley on BRDF studies and the BRDF/Albedo ATBD. Travel was supported by the BU Center for Remote Sensing.

8. The Principal Investigator interviewed Dr. Wolfgang Wanner, a physicist currently completing his doctoral studies at the University of Kiel, FRG, for possible employment on the MODIS contract. Dr. Wanner's work is planned to begin on the first of March, 1994.

PUBLICATIONS

The status of pending publications supported all or in part by this contract and its predecessor is shown below.

Submitted

The following manuscripts were submitted for publication during this reporting period:

Li, X., A. H. Strahler, and C. E. Woodcock, 1994, A hybrid geometric optical-radiative transfer approach for modeling albedo and dicretional reflectance of discontinuous canopies, IEEE Trans. Geosci. and Remote Sens., submitted.

Moody, A., and C. E. Woodcock, 1994, Scale-dependent errors in the estimation of land-cover proportions--Implications for global land-cover datasets, Remote Sens. Environ., submitted.

Barker Schaaf, C., X. Li and A. H. Strahler, 1994, Topographic effects of bidirectional and hemispherical reflectances calculated with a geometric-optical canopy model, IEEE Trans. Geosci. and Remote Sens., submitted.

Liang, S. and A. H. Strahler, 1994, An analytic radiative transfer model for a coupled atmosphere and leaf canopy, J. Geophys. Res., submitted.

Previously Submitted

The following manuscripts were previously submitted and are in the review process:

Liang, S. and A. H. Strahler, 1994, Retrieval of surface BRDF from multiangle remotely sensed data, to Remote Sens. Environ., submitted.

Liang, S., and A. H. Strahler, 1994, A four-stream solution for atmospheric radiance transfer over a non-Lambertian surface, Applied Optics, submitted.

Revised and Accepted

The following manuscripts were accepted for publication with revision, were revised, and resubmitted during this reporting period:

Barnsley, M. J., A. H. Strahler, K. P. Morris, and J.-P. Muller, 1993, Sampling the surface bidirectional reflectance distribution function (BRDF): Evaluation of current and future satellite sensors, Remote Sensing Reviews, in press.

Moody, A. and A. H. Strahler, 1993, Characteristics of composited AVHRR data and problems in their classification, Int. J. Remote Sens., in press.

Running, S., C. Justice, D. Hall, A. Huete, Y. Kaufmann, J-P. Muller, A. Strahler, V. Vanderbilt, Z-M. Wan, 1994, Terrestrial remote sensing science and algorithms planned for EOS/MODIS, Remote Sens. Environ., in press.

Lambin, E. F. and A. H. Strahler, 1994, Change-vector analysis: A tool to detect and categorize land-cover change processes using high temporal-resolution satellite data, Remote Sens. Environ., in press.

Lambin, E. F. and A. H. Strahler, 1994, Indicators of Land-Cover Change for Change-Vector Analysis in Multitemporal Space at Course Spatial Scales, Int. J. Remote Sens., in press.

In Press

The following manuscripts were in press during this reporting period:

Abuelgasim, A. A. and A. H. Strahler, 1993, Modeling bidirectional radiance measurements collected by the Advanced Solid-State Array Spectroradiometer (ASAS) over Oregon Transect conifer forests, Remote Sens. of Environ., in press.

Published (Copies provided separately)

Liang, S. and A. H. Strahler, 1993, Calculation of the angular radiance distribution for a coupled system of atmosphere and canopy media using an improved Gauss-Seidel algorithm, IEEE Trans. Geosci. and Remote Sens., vol. 31, pp. 491-502.

Schaaf, C. L. B., and A. H. Strahler, 1993, Modeling the bidirectional reflectance and spectral albedo of a conifer forest, Proceedings, 25th International Symposium on Remote Sensing and Global Environmental Change, April 2-8, 1993, Graz, Austria, vol. 2, pp. 594-601.

Schaaf, C. B. and A. H. Strahler, 1993, Solar zenith angle effects on forest canopy hemispherical reflectances calculated with a geometric-optical bidirectional reflectance model, IEEE Trans. Geosci. and Remote Sens., vol. 31, pp. 921-927.

Liang, S. and A. H. Strahler, 1993, An analytic BRDF model of canopy radiative transfer and its inversion, IEEE Trans. Geosci. and Remote Sens., vol. 31, pp. 1081-1092.